SOME FACTORS AFFECTING AND SUGGESTED WAYS FOR IMPROVING COAL MINE VENTILATION, WITH PARTICULAR REFERENCE TO MINES IN ILLINOIS, INDIANA, AND WESTERN KENTUCKY

By C. A. Herbert

Information Circular 7656

UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary
BUREAU OF MINES
J. J. Forbes, Director

Work on manuscript completed September 1952. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Information Circular 7656."

April 1953

Generated on 2024-09-20 10:48 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

SOME FACTORS AFFECTING AND SUGGESTED WAYS FOR IMPROVING COAL MINE VENTILATION, WITH PARTICULAR REFERENCE TO MINES IN ILLINOIS, INDIANA, AND WESTERN KENTUCKY

by

C. A. Herbert[1/]

CONTENTS

	Page
Summary	1
Introduction	1
Effect of lack of well-maintained air courses	2
Discussion of air losses	4
Faulty mining methods	8
Poor supervision	9
A suggested plan of mine development for the Central Coal Basin	11
Protection of roof in permanent air course entries	15

TABLE

1.	Results of a ventilation survey in 22 mines in the Central Coal Basin	5

ILLUSTRATIONS

Fig.		Follows page
1.	Typical working section where room-and-pillar panel method of mining is used. Haulage by shuttle car and track	8
2.	Suggested plan of mine development using a modified room-and-pillar panel system	10
3.	Enlarged section of sketch showing a suggested modified method of room-and-pillar panel development	12
4.	Self-closing split or double-swing doors used in conjunction with shuttle-car haulage at Princeton Mining Co., Princeton, Ind	12

1/ Mining engineer, Accident Prevention and Health Division, Region VIII, Vincennes, Ind.

Information Circular 7656

Generated on 2024-09-20 10:47 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

SUMMARY

This paper sets forth the hazards of accumulations of explosive mixtures of methane and air due to inadequate ventilation, the causes of which are discussed as follows:

1. Lack of well-maintained air courses.
2. Air losses due to leaky stoppings, trap doors, and overcasts.
3. Faulty mining methods.
4. Poor supervision.

A modified plan of room-and-pillar panel mine development is suggested, which, it is believed, will eliminate many of the hazards of gas accumulations inherent in the present method of mine development. It is also suggested that some waterproofing agent be used on the roof of permanent air-course entries in conjunction with roof bolting to eliminate the detrimental effect of the moisture-laden atmosphere during summer and thus prevent serious roof falls.

INTRODUCTION

Since the beginning of coal mining in Illinois, Indiana, and western Kentucky, there have been many major mine explosions in which five or more lives were lost and a still larger number of minor explosions that resulted in the death of less than five men. Many of the major explosions have been catastrophic in both loss of life and property damage; and some minor explosions, while causing the loss of few lives, have been widespread and have caused considerable property damage. A majority of these explosions were caused by accidental ignition of an accumulation of explosive gas. Although coal dust unquestionably was responsible for their propagation and violence, these widespread explosions probably would not have occurred had it not been for the accidental ignition of the body of gas.

In addition to these explosions, there have been numerous accidental ignitions of gas, which, in many instances, resulted in serious burns to underground employees and many times these serious burns were fatal.

Because of this record, and the fact that as little as 200 cubic feet of explosive gas-air mixture will, if ignited under favorable conditions, initiate a coal-dust explosion and that the presence of methane in the mine air increases the explosibility of coal dust to such an extent that additional rock-dusting is necessary,2/ the need for adequate ventilation to prevent gas accumulations is very apparent. In this connection, Section 209 (d) (1) of the Federal Coal-Mine Safety Act provides as follows:

2/ Owings, C. W., Methods of Allaying Dust in Underground Mining Operations: Bureau of Mines Rept. of Investigations 3631, 1942, 38 pp.; Suggested Methods for Installing Dust-Allaying Equipment in Bituminous Coal Mines: Bureau of Mines Rept. of Investigations 3843, 1945, 31 pp.

Generated on 2024-09-20 10:46 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

> All active underground working places in a mine shall be ventilated by a current of air containing not less than 19.5 per centum of oxygen, not more than 0.5 percentum of carbon dioxide, and no harmful quantities of other noxious or poisonous gases. The volume and velocity of the current of air shall be sufficient to dilute so as to render harmless, and to carry away, flammable or harmful gases.

The coal fields of Illinois, Indiana, and western Kentucky constitute what is known as the Central Coal Basin. The coal measures in this basin are virtually flat, except in parts of western Kentucky, where folding and faulting considerably disturbed the coal measures. The same is true to a much lesser extent in southern Illinois. The immediate roof over the coal beds throughout the basin is generally shale, and the floor under the beds is generally fire clay. Most coal beds of the Central Coal Basin now being worked are relatively thick, and, if enough well-maintained air courses are provided, ventilation should offer no serious problem.

Room-and-pillar mining is universal throughout the coal fields of the three States, and little attempt is made at pillar recovery for the following reasons: (1) The low purchase price per acre of coal rights; (2) the high value per acre of fertile farm lands overlying most of the coal beds and possible litigation because of damage to these lands as a result of complete or nearly complete extraction; and (3) cheaper production from mines in which pillars are not extracted.

In view of the many major and minor explosions and gas ignitions, it is apparent that the ventilation in many of the mines in these three States has at times been inadequate. This has been due, in large measure, to failure on the part of the operator to give proper consideration to future ventilation needs. It is easy to ventilate a new mine, but as years go by and resistance to the flow of air increases it becomes increasingly difficult to circulate enough air to prevent gas accumulations.

These gas accumulations are the result of one or all of the following causes: (1) Inadequate ventilation, which may result from lack of well-maintained air courses; (2) air losses due to leakage; (3) faulty mining methods; and (4) lack of proper supervision.

EFFECT OF LACK OF WELL-MAINTAINED AIR COURSES

The total pressure required to force air into a mine is equivalent to the resistance by the mine airways to the flow of air; therefore, it is apparent that to get more air into a mine it is necessary either to increase the ventilating pressure or to reduce the resistance to the air flow. There is an economic limit to the increase that can be made in ventilating pressure, and it is difficult to increase the number of air courses after the mine has been operating a number of years; therefore, in order that the resistance may be low, it is essential that enough well-maintained air courses are provided when the mine is opened.

Unfortunately, few mines in the Central Coal Basin were provided with enough air courses to take care of future ventilation needs, and, to add to the difficulties, the air courses that were provided are not properly maintained. In many instances these air courses have been permitted to cave and become obstructed to such an extent that it is impossible to force enough air through them to ventilate the mine properly even at excessive ventilating pressure.

Generated on 2024-09-20 10:47 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The condition of the airway surfaces, against which the ventilating current must rub, plays a very important part in both the amount of pressure and horsepower required to force a desired volume of air through the mine. The resistance of these surfaces may be increased considerably because of the rough, jagged condition of the roof and the rock falls on the floor. Because the area of the air courses is reduced by these falls, the velocity of the air current is proportionately increased, and, because the ventilating pressure required varies as the square of the velocity and the horsepower varies as the cube of the velocity, the unsatisfactory condition of so many air courses of the mines in the Central Coal Basin is responsible, in large measure, for the excessively high ventilating pressure required and the unnecessarily large power consumption by the fan. Therefore, to ventilate a mine with reasonably low ventilating pressure and power cost, it is essential that the air-course entries have a cross-sectional area large enough to permit the necessary volume of air to flow through them at low velocity. It is also necessary that the air-course entries be as smooth as possible and be kept clean and free of obstructions. Abrupt changes in cross-sectional area and abrupt turns should be avoided because both add materially to the resistance. It also has been found that timbering - cross bars, 3-piece sets, or center posts - adds substantially to the resistance, particularly where the velocity of the air current is high. It is in connection with this latter source of resistance that, it is believed, roof bolting will be of particular value by reducing, or possibly removing in some instances, the need for timber support.

While inspecting a large Illinois mine some years ago, one of the Bureau of Mines engineers found that inadequate ventilation resulted in a dangerously high percentage of methane in the return of several splits. The mine had a fine fan installation capable of delivering all the air the mine could use, but, because of obstructed and otherwise inadequate main air courses near the bottom of the ventilating shaft and because of leaky stoppings, the air was not getting to the face workings where it was needed. Following recommendations of the Bureau engineer, the coal company spent slightly over $3,500.00 in cleaning and improving the air courses and in stopping air leaks, particularly on the main air courses. After the improvements it was found that the resistance to the flow of air was reduced to such an extent that it was possible to decrease the ventilating pressure by slowing the fan, materially decreasing power consumption. At the same time, the quantity of air reaching the face workings was increased to such an extent that the methane content was reduced to within safe limits. Before the improvements were made, the power required was 104.5 kilowatts. After the improvements were made and the fan was slowed, the power requirement was found to be only 55.6 kilowatts - a saving of 48.9 kilowatts.

This mine operated entirely on purchased power, and $458.64 was saved per month on power consumption. In addition, $80.85 was saved on the demand charge, a total saving of $539.49 per month. The power saving paid for the cost of improvements in about 6-1/2 months, certainly a very profitable investment. At the same time, enough air was circulated in the mine to ventilate it properly.

In planning the development of a new mine, some thought also should be given to the size of the shafts and the size and number of air courses. If the shafts are too small in cross-sectional area for the amount of air that will be forced through them velocities will be excessively high, and the power loss in overcoming friction will be an appreciable item.

Generated on 2024-09-20 10:49 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from
THE OHIO STATE UNIVERSITY

At a large majority of the shaft mines in the Central Coal Basin, the hoisting shaft and the hoisting compartment in the air and escape shaft serve as either the upcast or the downcast of the mine. This is undesirable because the area usually is not large enough to permit the desired volume of air to pass, except at high velocity. In addition, movement of the cages or skips offers considerable resistance to the flow of air, as do the buntons supporting the cage or skip guides.

It would be highly desirable if separate compartments were provided solely for the passage of air and with cross-sectional areas large enough to permit the desired volume to flow through them at reasonably low velocity. The cost of shaft sinking is not directly proportional to the area of the shaft. For example, a shaft with a cross-sectional area of 300 square feet will not cost twice as much as one with an area of 150 square feet.

DISCUSSION OF AIR LOSSES

The air delivered by the fan must reach the face workings to ventilate the mine efficiently. The air losses between the downcast opening and the face regions are due to leaky stoppings between the intake and return air courses, ill-fitting and leaky trap doors, and poorly constructed and leaking overcasts. As the mine workings advance with the ever-increasing number of sources for air leaks, it is necessary to increase the ventilating pressure continually to insure that the necessary volume of air is ventilating the faces. This increase of ventilating pressure with the accompanying increase of air losses adds to the velocity of the air along the airways.

High-velocity air currents have three very decided drawbacks, particularly in dry, dusty mines:

1. On haulage roads the fine coal dust is blown off the cars and adds materially to the coal-dust-explosion hazard.

2. The fire hazard is increased considerably, and a small fire will soon spread to such an extent that it may be out of control by the time it is discovered.

3. In the winter, when the humidity of the intake air is low, large volumes of air forced along the entries keeps them dried out and adds to both fire and explosion hazards.

Someone has said that, if air leaks were visible, the same as leaks in a water line, they would soon be stopped. No company would continue to pump water out of a mine through a pipeline that leaked to such an extent that over half of the water delivered by the pump leaked out between the pump and the top of the shaft, requiring a pump of over twice the necessary capacity, yet this is just exactly what is happening in ventilating many of our coal mines today. Doubtless the cost of operating this larger pump, owing to the leaky discharge line, would be small compared with the added cost of operating the fan because of air leaks in the mine.

In a recent ventilation survey in 22 mines in the Central Coal Basin, the percentage of air lost by leakage before reaching the active workings was determined and is shown in column 7 of table 1. By referring to this table, it will be observed that the percentage of air loss varies between 8.9 and 70.7 percent.

Generated on 2024-09-20 10:46 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 1. - Results of a ventilation survey in 22 mines in the Central Coal Basin

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10
Mine No.	Water-gage pressure, inches	Volume of air entering mine, c.f.m.	Split No.	Volume of air reaching active workings, c.f.m.	Volume of air lost, c.f.m.	Percentage of loss	Percentage of methane in intake air reaching active workings	Cu. ft. of methane entering intake air per hour	Computed horsepower required to operate fan
1	1/0.2		1	25,000			0.00	-	
			2	30,200			.11	2,000	
			3	13,500			.00	-	
		75,600	Total	68,700	6,900	9.1		2,000	4
2	1/.25		1	23,500			.04	600	
			2	19,000			.05	600	
			3	18,000			.10	1,000	
		67,300	Total	60,500	6,800	10.1		2,200	4
3	1/.75		1	27,000			.17	3,000	
			2	23,000			.08	1,100	
			3	21,000			.09	1,100	
		86,000	Total	71,000	15,000	17.4		5,200	16
4	.8		1	22,000			.04	500	
			2	28,000			.35	6,000	
			3	33,000			.00	-	
		91,000	Total	83,000	8,000	8.9		6,500	18
5	1.12		1	15,300			.00	-	
			2	36,500			.00	-	
		57,400	Total	51,800	5,600	9.8		-	16
6	1.4		1	31,600			.08	1,500	
			2	8,000			.00	-	
		45,800	Total	39,600	6,200	13.5		1,500	16
7	1.4		1	16,400			.00	-	
			2	15,900			.17	1,600	
			3	26,900			.00	-	
		79,400	Total	59,200	20,200	25.4		1,600	27
8	1.6		1	23,600			.02	300	
			2	24,600			.00	-	
			3	17,600			.15	1,600	
		87,100	Total	65,800	21,300	24.2		1,900	34
9	2.25		1	21,000			.07	900	
			2	23,900			.19	2,700	
			3	22,800			.20	2,700	
		102,900	Total	67,700	35,200	34.2		5,300	57
10	3.0		1	15,400			.11	1,000	
			2	5,000			-	-	
			3	14,500			.00	-	
			4	4,000			-	-	
		70,400	Total	38,900	31,500	44.5		1,000	52
11	1.75		1	23,900			.00	-	
			2	23,400			.00	-	
			3	18,900			-	-	
		66,300	Total	66,200	100	None			29
12	3.25		1	16,200			.00	-	
			2	13,300			.00	-	
			3	8,800			.00	-	
			4	13,100			.00	-	
		117,000	Total	51,400	65,600	56.1		-	93
13	3.50		1	23,500			.05	700	
			2	22,200			.00	-	
			3	20,300			.00	-	
			4	14,600			.07	600	
			5	17,500			-	-	
			6	10,100			.00	-	
			7	25,300			-	-	
		156,400	Total	133,500	22,900	14.6		1,300	134

1/ New mines.

Generated on 2024-09-20 10:48 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 1. - Results of a ventilation survey in 22 mines in the Central Coal Basin (Cont.)

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10
Mine No.	Water-gage pressure, inches	Volume of air entering mine, c.f.m.	Split No.	Volume of air reaching active workings, c.f.m.	Volume of air lost, c.f.m.	Percentage of loss	Percentage of methane in intake air reaching active workings	Cu. ft. of methane entering intake air per hour	Computed horsepower required to operate fan
14	3.8		1	20,800			0.04	500	
			2	25,900			.06	900	
			3	23,800			.09	1,300	
		141,600	Total	70,500	71,100	50.2		2,700	132
15	3.8		1	14,400			.00	-	
			2	16,800			.00	-	
			3	21,600			.03	400	
			4	13,300			.03	600	
		135,200	Total	66,100	69,100	51.1		1,000	126
16	4.0		1	21,800			0.16	2,000	
			2	29,400			.10	1,800	
			3	19,000			.28	3,200	
			4	16,100			.75	7,200	
		139,700	Total	86,300	53,400	38.2		14,200	137
17	4.5		1	2,700			.00	-	
			2	10,100			.00	-	
		24,000	Total	12,800	11,200	46.7			27
18	8.2		1	16,800			.00	-	
			2	15,000			.08	700	
			3	18,500			.00	-	
			4	15,200			.00	-	
		97,800	Total	65,500	32,300	33.0		700	197
19	5.0		1	18,500			.00	-	
			2	22,300			.00	-	
			3	18,000			.05	500	
		153,900	Total	58,800	95,100	61.8		500	189
20	5.8		1	14,900			.05	400	
			2	8,500			.03	200	
			3	12,700			.04	300	
		52,500	Total	36,100	16,400	31.2		900	75
21	3.8		1	11,000			.15	1,000	
			2	34,600			.02	400	
		110,800	Total	45,600	65,200	58.8		1,400	103
22	6.3		1	7,300			.19	800	
			2	9,200			.15	800	
			3	8,900			.18	1,000	
			4	12,300			.25	2,000	
		128,700	Total	37,700	91,000	70.7		4,600	199

Generated on 2024-09-20 11:03 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

To cut down air losses, the place to begin is at the downcast and work toward the face. The ventilating pressure between the downcast and the first overcasts is higher than elsewhere in the mine; and, as a result, the amount of air that will leak through small openings in or around a stopping will be correspondingly greater. Then, too, the stoppings in this portion of the mine, having been the first to be built, are more likely to have deteriorated, causing leaks due to loosening and breaking of the roof and cracking and rashing of the coal at the ends of the stoppings.

It will, of course, be impossible to prevent all loss of air; however, it should be possible in any mine to reduce the leakage to reasonable limits. At least the loss should not, in any instance, exceed 20 percent. To this end it would be highly desirable for the operating company to make occasional checks to determine how much air is being lost through leakage and where along the entries this loss is taking place. If this were done and the leaks thus found were stopped, a larger percentage of air entering the mine would reach the face workings where needed. At the same time, a considerable amount could be saved in the power consumed in operating the fan.

Column 2 of table 1 gives the water-gage pressure at the various mines covered by this survey. It will be observed that several mines are operating with an excessively high ventilating pressure, which indicates that there are not enough air courses or that they are not being maintained properly. This high ventilating pressure resulting from such neglect of the air courses also results in excessively high power bills, as has been pointed out previously in this paper.

Throughout the Central Coal Basin it should be possible to properly ventilate the mines with a ventilating pressure corresponding to not over 3 inches of water gage.

Column 10 of table 1 shows the calculated horsepower required to drive fans at each of the mines visited. In the few mines where it was possible to obtain definite figures on the power input to the fan unit, it was found that the mechanical efficiency was approximately 64 percent. Although it is believed that this efficiency is a little high, it was used in computing the horsepower shown in table 1. It will be interesting to note the great variance in the amount of horsepower required to ventilate these mines, indicating very clearly the condition of the mine airways.

Of the mines listed in table 1, mine 22 is the most glaring example of the result of excessive air losses; only 29.3 percent of the air being delivered by the fan, or 37,700 cubic feet per minute, was reaching the active workings. To deliver this comparatively small quantity of air required a power input to the fan of 199 horsepower. While this is the worst example, there are a number of others - mines 12, 14, 15, 19, and 21 - which also had excessively high air losses and the accompanying high power input to the fan.

Compare these examples with mine 5, where the fan is delivering 51,800 cubic feet of air per minute to the active workings against a water-gage pressure of 1.12 inches and requires only 16 horsepower; and mine 2, where the fan is delivering 60,500 cubic feet of air per minute to the active workings against a water-gage pressure of 0.25 inch, requiring only 4 horsepower.

It is believed that the above examples show quite clearly the power savings that can be made by preventing air losses and by furnishing an adequate number of well-maintained airways.

Generated on 2024-09-20 10:54 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

FAULTY MINING METHODS

The mines in Illinois, Indiana, and western Kentucky are generally operated on what is known as a room-and-pillar panel-entry system, except in small mines and mines in western Kentucky, where the coal beds dip because of faulting. Under this method, panel entries are turned right and left off submain entries (also known as cross entries). These panel entries are usually driven in pairs to an approximate depth of 1,000 feet and have rooms turned off both entries. Recently, a third and often a fourth entry sometimes is driven after passing through the barrier pillar. These latter entries are used to facilitate haulage, particularly in connection with combination shuttle-car and rail haulage. Usually, a barrier pillar of about 100 feet is left between the first room and the cross entry. The thickness of the barrier pillar, however, will vary, depending on the thickness of the overburden. The only openings from the cross entries to the panels are the two panel entries themselves. After a panel is finished the panel entries are usually sealed off near the cross entries. (See fig. 1.) Only the two openings to the panel are made through the barrier pillar to keep to a minimum the necessary number of seals.

The usual practice has been to ventilate panels and the face of the cross entries on one continuous circuit. In fact, quite often not enough air reaches the face workings in the cross entries to permit splitting the air; otherwise, if this were done the air velocity would be so decreased that accumulation of gas could not be prevented if feeders were uncovered during mining. In some mines that do have enough ventilation to permit splitting the air, the working panels at the face of the cross entries are on separate splits, improving the ventilation and making it unnecessary to use one trap door.

As will be observed by referring to figure 1, unless it is possible to put one of the panels on a separate split, it is necessary to have at least two trap doors at the entrance to each working panel. Each time one of these doors is open during haulage the air is momentarily short-circuited. Sometimes these trap doors are propped open by the haulage crew to avoid stopping to open them when returning with loaded cars, thus the doors may be open for some time, cutting off most of the ventilation in these panels and allowing explosive mixtures of gas to accumulate. In addition, as the panel entries are finished they are usually sealed, leaving a succession of pent-up reservoirs of flammable or explosive gas for the entire length of the cross entries from the main entries to the working sections. This gas may find its way out onto the cross entries if the seals leak and, in the case of the intake entries, flow into the working sections.

During periods of rapidly falling barometric pressure the pressure between the inside and outside of the seals becomes unbalanced. The pressure of the pent-up gas within the sealed area will be much higher than that outside the seals; thus, if there are any leaks in the seals at all, the gas will flow from the sealed areas into the mine entry. This has occurred on numerous occasions; in fact, at some mines a close watch is kept of the barometer, and if it falls rapidly, particular vigilance is used to make sure that dangerous quantities of explosive gas have not leaked into the active workings; in some instances it has been found necessary to discontinue operation of the mine temporarily.

During the recent ventilation survey, samples were taken on intake air just outby the active workings at points where air measurements were also made. The results of these samples are shown in column 8 of table 1 and indicate the percentage of methane in the intake air that has leaked into the air from old and abandoned workings, the

Generated on 2024-09-20 10:52 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-20 10:58 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

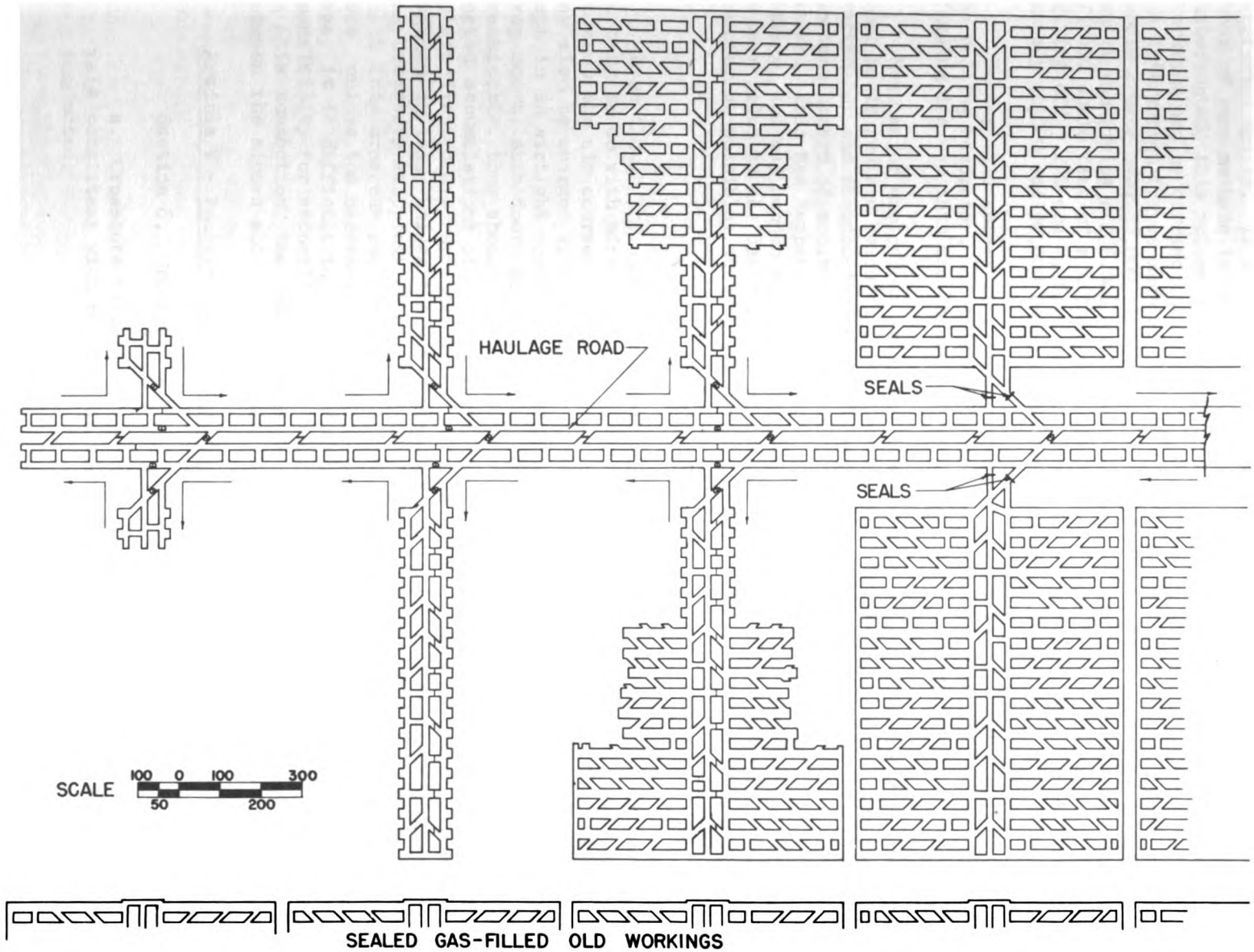


Figure 1. - Typical working section where room-and-pillar panel method of mining is used. Haulage by shuttle car and track.

Original from THE OHIO STATE UNIVERSITY

majority of which are sealed. Column 9 of this same table shows the corresponding number of cubic feet per hour of pure methane leaking into the intake air on the different splits. In a large percentage of instances, over 1,000 cubic feet per hour of pure methane is leaking into the intake air. As long as ventilation is not interrupted, this volume of methane will merely add to that given off in the face workings and be carried out of the mine with the return air. However, if ventilation is interrupted for as much as 1 hour, 1,000 cubic feet of methane mixed with air would create over 12,000 cubic feet of a highly explosive mixture. In mine 4 one split was giving off 6,000 cubic feet per hour of methane, which would create over 75,000 cubic feet of a highly explosive mixture, and in mine 16 two splits were giving off 3,200 and 7,200 cubic feet per hour of methane, which would create approximately 40,000 and 90,000 cubic feet, respectively, of a highly explosive mixture.

During this survey no attempt was made to take these samples at a time of low or falling barometer. If this had been done, doubtless the percentage of methane finding its way into the intake air would have been much greater.

Many major explosions, with the loss of many lives, have occurred in the Central Coal Basin and are believed to have been caused by the ignition of gas emanating from worked-out and abandoned panels. In addition to the above, there is also the ever-present hazard of active workings accidentally breaking through into these abandoned areas. This has happened in the past, with considerable loss of life and property damage, and may happen again despite the precautions that may be taken. These disasters point to the desirability of a change in current mining methods to prevent, insofar as possible, occurrences of this kind.

POOR SUPERVISION

Even though the underground supervisory force at a mine probably has little or nothing to do with mine lay-out, it may quite properly be charged with any failure to keep the air courses clean and free of roof falls and other obstructions. It may also be charged with failure to have crosscut stoppings properly installed and kept in an airtight condition and with permitting poorly built and poorly erected trap doors; such doors should be tight and so hung as to be self-closing; where practicable, they should be hung in pairs to form air locks. The fact that undetected accumulations of gas are permitted to occur in working sections, owing usually to misdirected air currents, is prima facie evidence that supervision in the face regions is lax. Unless the air current is forced to the last room crosscut by placing necessary stoppings or curtains outby this last crosscut, enough air will not reach this crosscut and, in addition, if considerable gas is being liberated at the face, unless the necessary line brattices are used from the last crosscut to the face, it is difficult to prevent accumulations of gas at the room faces. The responsibility for accomplishing this lies directly upon the supervising officials. In this connection, the Federal Mine Safety Code, which forms part of the contract between the miners and operators, provides as follows:

Article V - Ventilation and Mine Gases

Section 6. Crosscuts and stoppings.

a. Crosscuts between entries and rooms should be made at intervals consistent with practice in the States where mine operations are conducted.

Generated on 2024-09-20 10:53 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

b. Crosscuts between entries should be closed, except the last one in a pair or set of entries.

c. Where necessary to obtain a movement of air to the face of a room to clear the room of flammable or noxious gases, crosscuts between rooms should be closed, except the one nearest the face.

d. Where practicable, a crosscut should be provided at or near the face of each entry or room before the place is abandoned.

e. Entries, rooms, or chutes should not be turned off an entry beyond the last crosscut * * * * *.

f. On entries other than room entries, stoppings in crosscuts between intake and return airways should be built of solid, substantial, incombustible material, such as concrete, concrete blocks, brick, or tile.* * * * * * * *.

Underground officials are responsible for making thorough preshift examinations for methane accumulations and provisions for their removal, frequent examinations for methane and prevention of gas accumulations during the working shift, and tests for gas in the working places before each piece of electrical equipment is taken to the face, and frequent tests during operation of such equipment. These examinations are now required by the Federal Coal-Mine Safety Act.

In addition to this responsibility for the safety of the men and proper ventilation of the working places, the officials are responsible for producing coal; and, should anything go wrong with any of the equipment necessitating attention, there is the possibility that for the time being necessary tests for gas may be neglected. This has occurred in the past and has been responsible for failure to detect gas that has accumulated. In other words, the first responsibility of the face boss in a gassy mine should be to look after the ventilation of the working places to make certain that gas accumulations are detected; if his other responsibilities make this uncertain, enough employees should be appointed in gassy mines to make these frequent tests.

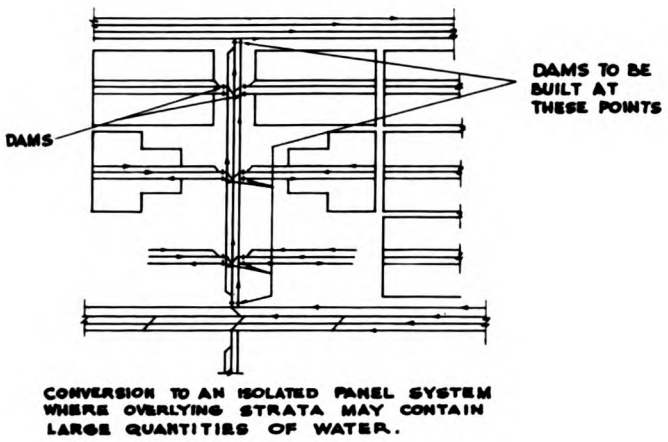
Sometimes a fire boss starts his examinations too early, giving an opportunity for gas to accumulate between the time his tests are made and the beginning of the working shift; this is covered by the Federal Coal-Mine Safety Act as follows:

Section 209(d) (7)

In a gassy mine, within four hours immediately preceding the beginning of a coal-producing shift, and before any workmen in such shift other than those who may be designated to make the examinations prescribed in this paragraph enter the underground areas of such mine, certified persons designated by the operator of such mine to do so shall make an examination, as prescribed in this paragraph, of such areas.

Gas usually accumulates between the last crosscuts and face because of failure to deflect sufficient air from the last crosscut to the face. If ample air is reaching the face workings and is not being properly utilized, accumulations of gas can be charged to lack of face supervision. However if there is not enough air reaching the face workings, lack of proper supervision on the part of higher officials may be responsible.

Generated on 2024-09-20 10:48 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY


DAMS TO BE BUILT AT THESE POINTS
DAMS
CONVERSION TO AN ISOLATED PANEL SYSTEM WHERE OVERLYING STRATA MAY CONTAIN LARGE QUANTITIES OF WATER.

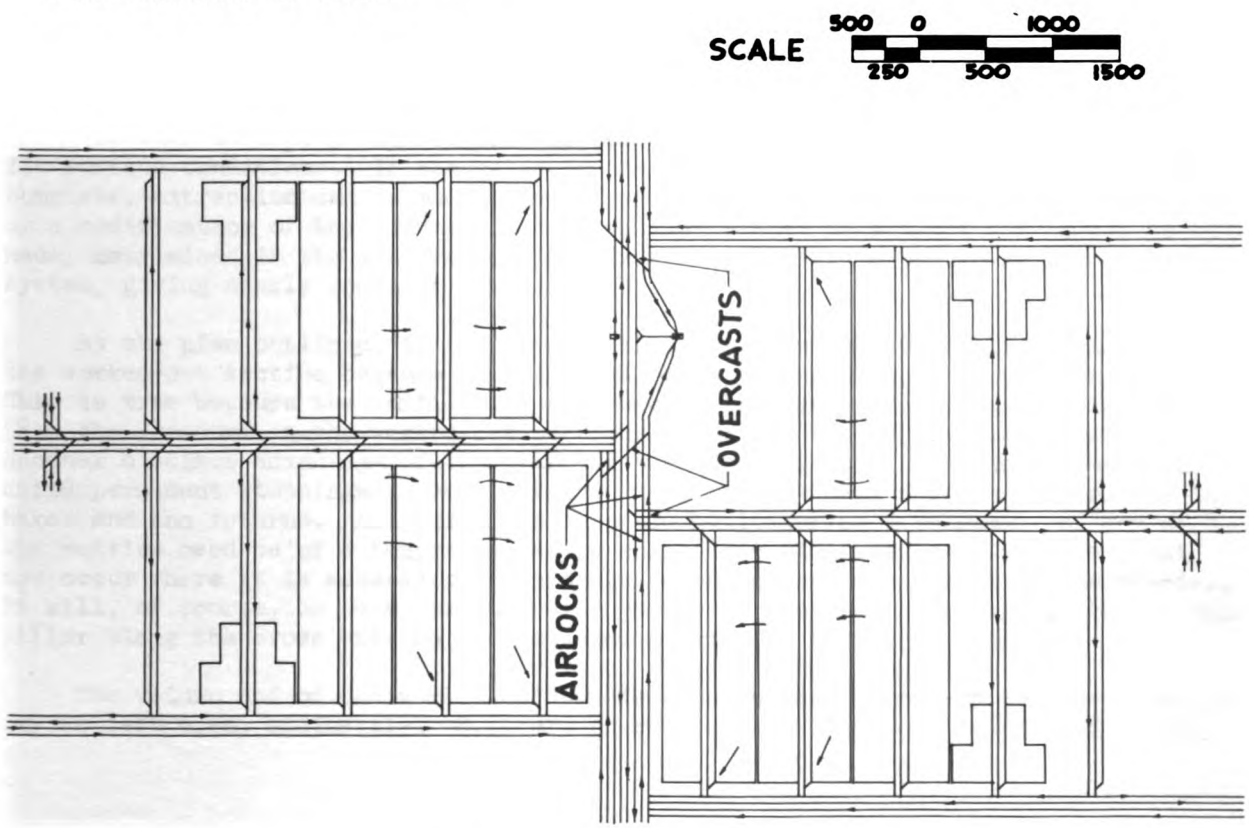


Figure 2. - A suggested plan of mine development using a modified room-and-pillar panel system.

Generated on 2024-09-20 10:51 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

SUGGESTED PLAN OF MINE DEVELOPMENT FOR THE CENTRAL COAL BASIN

Figure 2 shows a suggested modified plan of the room-and-pillar panel method of mining, which it is believed could be used throughout the Central Coal Basin to remove many of the disadvantages and hazards inherent to the present panel system. This envisions a mine laid out to work a rather large area of coal acreage. From the hoisting and air shafts eight main entries are driven in opposite directions, the four center entries being intake air courses and the two pairs of outer entries serving as return air courses. Cross entries consisting of two pairs of double entries are driven right and left from the main entries on each side of the shaft.

The above-stated plan differs from the present method, in that the four entries of the cross entries are all on intake and that the air flows from the cross entries through the panel entries to the return entries, which also consist of four entries driven in sets of two. The panel entries, it is suggested, should be approximately twice the length of the present panels.

Therefore, instead of having approximately 18 rooms on each entry, as the average panels in this area do, there will be approximately 36 rooms on each panel entry. This system can be varied to suit conditions. It is believed that the number of rooms should be some multiple of the number of rooms required for a day's operation of a loading unit, which would vary with the capacity of the loading machine and the thickness of the coal bed. As will be observed, the first group of rooms on each panel entry will be begun next to the return entries, or bleeder entries, and will progress outby toward the cross entries.

The suggested plan will enable the operator to vary the amount of extraction to fit surface conditions. If the value of the land is such that complete, or nearly complete, extraction can be made, the pillars may be nearly or completely extracted or a modification of the present room-and-pillar system to a block system can be made; many mines in the eastern coal fields are operating on the so-called block system, giving nearly complete extraction.3/

By the plan outlined, it can be seen that the rooms can be holed through into the worked-out section because the ventilation is all away from active workings. This is true because the ventilating pressure in the active workings will be higher than the pressure in the worked-out sections or in the return or bleeder entries. Another distinct advantage of the proposed plan is that it will be unnecessary to build permanent stoppings between entries except on the main entries between the intakes and the returns. All stoppings that are built during development of any of the entries need be of a temporary nature only; this will prevent air losses that now occur where it is necessary to maintain permanent stoppings between the entries. It will, of course, be necessary to build permanent seals or stoppings in the barrier pillar along the cross entries in the panel entries as they are completed.

The return end of the worked-out panels adjacent to the return or bleeder entries may be left open, ordinarily. However, there are a few sections in central Illinois

---

3/ Haley, Wilbur A., Shields, Joseph J., Toenges, Albert L., and Turnbull, Louis A., Mechanical Mining in Some Bituminous-Coal Mines. Progress Report: Extraction of Pillars with Mechanized Equipment: Bureau of Mines Inf. Circ. 7631, May 1952, 64 pp.

Generated on 2024-09-20 10:47 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

where (1) the value of the farm lands overlying the coal is so high as virtually to prohibit the recovery of any pillars, and (2) gob fires occur occasionally if the worked-out sections are ventilated or partly ventilated. In the few sections where gob fires occur, it would undoubtedly be desirable to erect stoppings or seals at the return end of the abandoned panels. A steel door should be in one of these stoppings. This door should be equipped with bolts and wing nuts so that it could be closed and made airtight in case of fire. As a precautionary measure to prevent roof falls breaking over these seals (on cross entries and bleeder entries), the entries should be timbered with steel crossbars on close centers that are hitched into the ribs on both sides where the seals are to be built, and also should be supported by auxiliary center posts or other means of support. It also might be desirable to install an occasional steel door in the seals on the intake or cross entry end of the panels where extraction is complete or nearly complete in order that, if desired, the worked-out area may be more completely ventilated. In areas where fires do occur occasionally and pillars are not recovered, it would not be desirable to hole the active workings in the worked-out panels, but rather to leave a thin pillar of coal between panels; however, the door at the bleeder entry or return side should be kept open so that, in case of an accidental break into this recently abandoned panel, the flow of air would be from the active workings toward the abandoned ones. It is believed that ordinarily the steel door may be left open, as it is thought there is little likelihood of serious gob fires occurring if seals on the intake end of the panels have been built that leave only the one opening in the seal at the return- or bleeder-entry end.

If, for any reason, because of the amount of coal to be extracted cross entries will be much more than 1 mile in length, it would be desirable to drive a set of four entries, two intakes and two returns, parallel to the main entries and on each side of them. The first pair of cross entries on each side of the shafts would serve as intake splits to these parallel main entries; and, as these parallel entries advanced, subsequent return or bleeder entries and cross entries would be connected to them. Using this plan of development, the velocity of the air current will be kept reasonably low and the mine can be ventilated with minimum ventilating pressure and power consumption.

A solid pillar of coal is left between two sets of parallel entries with the air traveling in the same direction in all four entries so that emergency trap doors at desirable points along the entries can be closed on either pair of entries, quickly isolating a fire should one occur but still maintaining ventilation through the remaining two entries.

As development progresses, regulator doors will have to be erected at the return end of the panel entries, to control the volume of air through these panel entries. Curtains or temporary swing doors should be put on the entry between the first and second rooms and the last and next to the last rooms in order to divert the air up to the working faces; also, curtains or temporary stoppings should be put in the crosscuts between the first and second rooms and the last and next to last rooms in the groups of rooms being driven. More air will be required for this plan of mining than for the present plan, but the ventilation will be better, and there will be less opportunity for gas to accumulate and certainly less likelihood of breaking into abandoned, gas-filled areas.

Three panel entries are shown (fig. 2), two of which are cut through to the cross entries and to the return, or bleeder, entries, the center one serving as the

Generated on 2024-09-20 10:53 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-20 10:49 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

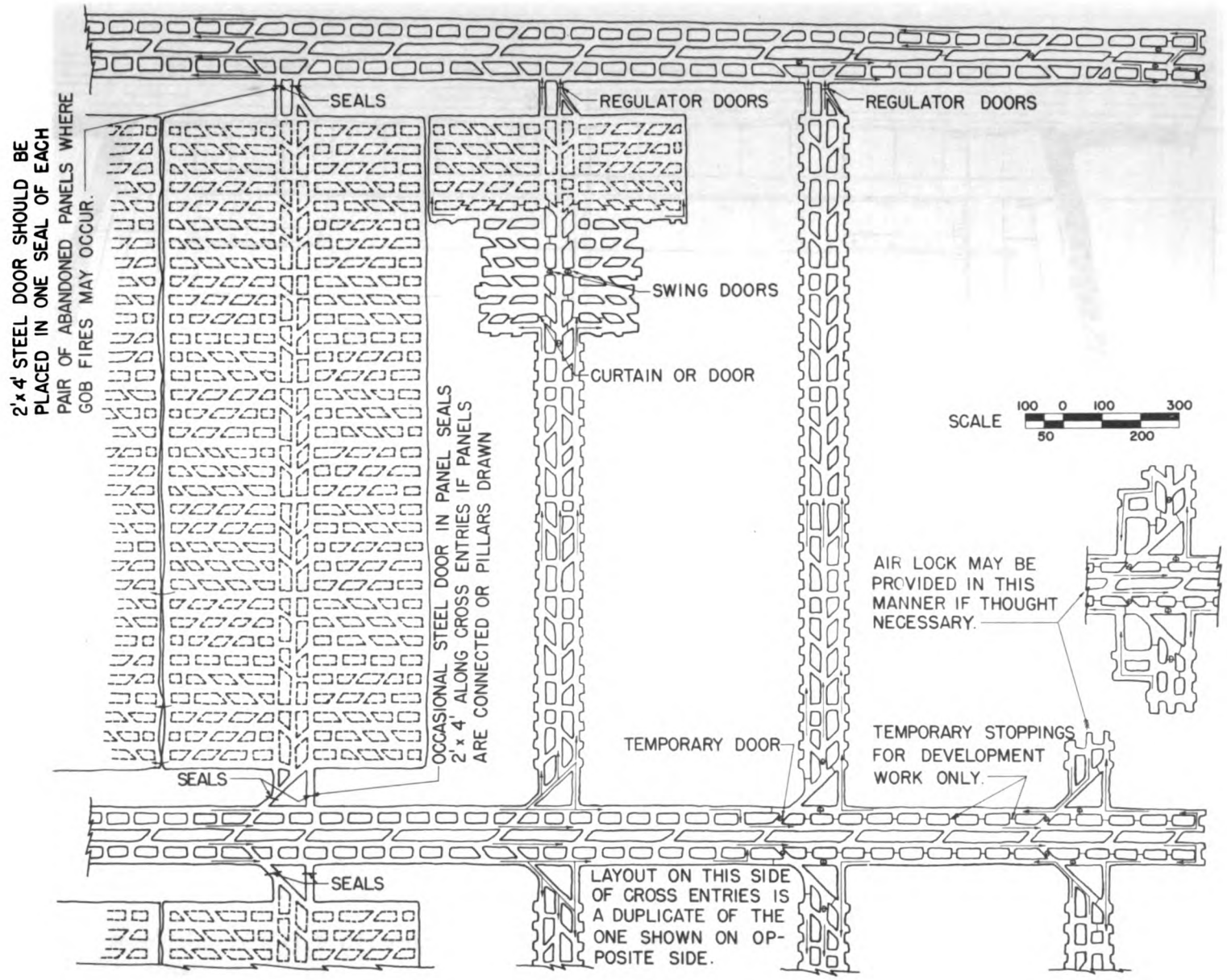

2'x 4' STEEL DOOR SHOULD BE PLACED IN ONE SEAL OF EACH PAIR OF ABANDONED PANELS WHERE GOB FIRES MAY OCCUR.
SEALS
REGULATOR DOORS
REGULATOR DOORS
SWING DOORS
CURTAIN OR DOOR
OCCASIONAL STEEL DOOR IN PANEL SEALS 2'x 4' ALONG CROSS ENTRIES IF PANELS ARE CONNECTED OR PILLARS DRAWN
SCALE 100 0 100 300 50 200
AIR LOCK MAY BE PROVIDED IN THIS MANNER IF THOUGHT NECESSARY.
TEMPORARY DOOR
TEMPORARY STOPPINGS FOR DEVELOPMENT WORK ONLY.
SEALS
SEALS
LAYOUT ON THIS SIDE OF CROSS ENTRIES IS A DUPLICATE OF THE ONE SHOWN ON OPPOSITE SIDE.

Figure 3. - Enlarged section of sketch showing a suggested modified method of room-and-pillar panel development.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-20 10:52 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

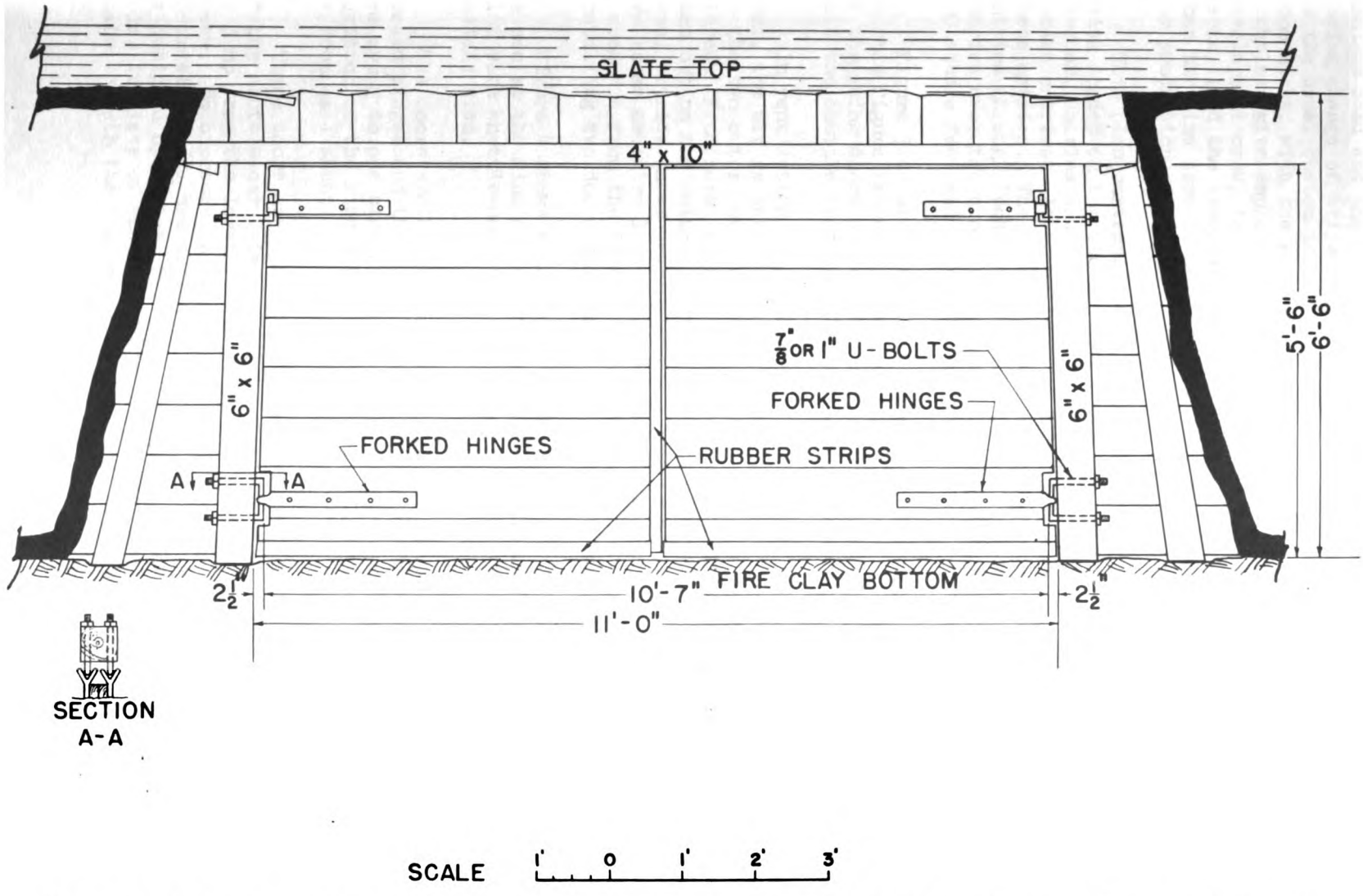


Figure 4. - Self-closing split or double-swing doors used in conjunction with shuttle-car haulage at Princeton Mining Co., Princeton, Ind.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

haulage road and the third entry serving as a parting or empty track to be used during change of trips on the center entry. While driving these panel entries it is the usual custom throughout the field to make two cuts in the room necks. These room necks, with the necessary crosscuts and the driving of the panel entries, will doubtless give ample coal for a loading unit. In some mines in this field the development crew, in addition to driving the panel entries and turning the room necks, laid the track and switches and installed the necessary swing doors so that when the time came to begin driving the rooms on these entries everything was ready for production.

This plan contemplates using shuttle cars from the loading unit to the cars being loaded on the center track. A track should be maintained in the return, or bleeder, entries and in one of the two return entries on each side of the four main intake entries. It is believed this is necessary to insure proper maintenance of these entries. The track in the main return entries can connect with the cross entries through locked doors at these cross entries. Overcasts built on the return entries over the cross entries should have a cross-sectional area of not less than 100 square feet and should be as smooth and regular as possible.

Figure 3 is an enlargement showing the development of a set of cross entries. On this figure there is shown one set of panels on which is indicated the location of the swing doors and slant crosscuts customarily used in this field in conjunction with the shuttle cars and mine cars.

In ventilating the face of the cross entry and the panel entries under development, the air is taken in on the two center entries of the cross entries and returns on the two outer entries to the last panel entry in which development has been completed. From here it is conveyed to the face of the return or bleeder entries and then out on the return entry. This will necessitate a trap door on the pairs of panel entries under development. Should an air lock be deemed necessary, the first two rooms on entry 1 of the panels may be driven far enough to provide room to drive a crosscut from the face of room 1 through the barrier pillar. This will allow for installing two doors to form an air lock, as indicated on figure 3.

Figure 4 shows a double swing door or split door, as it is sometimes called, in use at the King's mine of the Princeton Mining Co., Princeton, Ind., in conjunction with shuttle-car haulage. This same type of door is used in other mines in Indiana also.

The doors are hung from the top hinges and held in place at the bottom with two forked hinges and their own weight, one hinge on either side of each door. As they are swung to one side by the shuttle car, the doors are tilted up because of the position of the hinges that are engaged; this causes them to swing back into place as soon as a shuttle car has passed.

These doors have proved quite satisfactory but have one objectionable feature. If the shuttle-car driver is careless and hits the doors too hard they are likely to jump from the lower forked hinges and will not close until they are put back in place. To overcome this, George C. Ritter, a former employee of the Ingle Coal Co., Elberfeld, Ind., has devised a lower hinge that removes this difficulty. This hinge, as designed by Ritter, has two lugs extending down below the door, one on either side, in place of the forked hinges. These lugs engage in curved slots in a steel plate beneath the door and hold the door securely in place in all positions. These

Generated on 2024-09-20 10:48 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

curved slots are cut on the radius of a circle, with its center at the center of the lug. A patent on this lower hinge is pending. The doors consist of a two-ply wooden frame to which sections of old conveyor belting are secured. This makes a light and very satisfactory door. Another unique feature of the doors used at the Ditney Hill mine is that, instead of the customary wooden door post, a steel-pipe timber jack is used. When it is necessary to install the door somewhere else it is easily disassembled by loosening the jack.

If belt haulage is used throughout, a man-trip and supply track must be maintained in each set of intake entries. Therefore, it is necessary to underpass the main belt to get into the cross entries on the opposite side and to underpass the discharge end of the cross-entry belt as well as the discharge end of the panel-entry belts.

When belt haulage is used the development of entries will doubtless be done by means of the supply track and cars. It is thought these cars could be of the drop-bottom variety which would enable them to be run over dumping points and the coal conveyed up onto the belt.

The amount of development necessary to maintain this modified panel system, as in almost any other system where the coal is loaded mechanically, will depend on the tonnage desired, the thickness of the coal, and the capacity of the loading unit per shift. In the Illinois No. 6 bed the loading units have an average capacity of a little over 600 tons per shift. One set of cross entries will have a working panel on either side operating in rooms with two loading units per panel. In addition, two loading units probably will be required for development, making a total of six units, which will produce approximately 3,500 tons per shift, or a total capacity of approximately 7,000 tons per working day of two shifts.

If a greater tonnage than this is required, or in thinner coal where the capacity of the loading units is less, it will be necessary to maintain two cross entries and utilize a requisite number of loading units to provide the desired tonnage.

Inasmuch as the proposed modified plan of mine development is merely a derivation of the present panel method, it is thought that, in many mines where the present plan of panel mining is being used, it would be possible to change to the proposed plan without too much difficulty. This would consist largely of connecting the panel entries from adjacent cross entries and making the cross entries alternate intake and returns or bleeder entries.

Under some conditions, isolated panels may be necessary. For example, some mines in the Terre Haute, Ind., area are mining coal under the Wabash River bottoms, and when a break in the roof occurs the panels are usually flooded. To protect the balance of the mine, heavy concrete dams are built in the panel entries just inby the cross entries to retain the water in the panel where the break has occurred. Therefore, instead of having a gas hazard there is a water hazard and precautions must be taken to keep from breaking through into these water-filled panels. The same is also true, to a smaller extent, in some other areas where the coal is being mined under gravelly formations containing large volumes of water and it is necessary to erect dams to prevent flooding of other sections of the mine. If the above suggested modified panel system is adopted and it becomes necessary, because of

Generated on 2024-09-20 10:47 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

water hazards, to change to the isolated panels so that each panel might be dammed off separately from the others, the panel entries can be used as short cross entries from which the isolated panels are turned. (See fig. 2.) By this means, the first two panels will be turned next to the return, or bleeder, entries and succeeding panels driven outby toward the intake entries. The worked-out sections will always be on the return side next to the bleeder entries, whereas the new panels will be on the intake side. However, it will be necessary to have one trap door in each panel in the first slant crosscut near the mouth of the entries.

Protection of Roof in Permanent Air-Course Entries

Experiments at the Central Experiment Station, Pittsburgh, Pa., by Hartmann and Greenwald[4/] have shown that interchange of moisture between the atmosphere and argillaceous shales causes far more expansion and contraction of the shales than temperature changes. It is thought that it is because of this expansion and contraction that so much difficulty is experienced with the cutting and spalling of the roof shales during the summer. These experiments have also shown that application of waterproofing paints helps to prevent absorption of moisture by the shales. Several experimental applications of waterproofing material have also been made in mines with varying degrees of success. In many of these trials, applications were made on unsupported sections of roof that had been exposed to the atmosphere for long periods; no doubt, the shale had been greatly weakened because of this exposure. Although an attempt was made to scale off all loose material, much of the structural strength of the roof shale had been lost because of this long exposure, and application of the waterproofing paint was not entirely successful in preventing roof falls. It is believed that to be most successful and provide a valuable adjunct to roof bolting, waterproofing material should be applied to the freshly exposed roof as a part of the regular operating cycle, before any deterioration due to atmospheric conditions has begun.

Tests conducted at the Central Experiment Station indicated that Pittsburgh coal and "rooster" coal lying above the Pittsburgh bed show very little, if any, expansion resulting from the absorption of moisture, even though the coals are immersed in water.[5/] It similarly appears that the coals of the Central Coal Basin also expand but little because of moisture. Where top coal is left in place in mine entries and properly supported, it has remained intact for a long time. In mines recently opened, where top coal has been left in place on the entries and is supported by roof bolts, little difficulty is experienced with the roof on either intake or return air courses.

It is, therefore, believed desirable to leave the top coal in place in the air courses and permanent entries where the thickness of coal will permit it. Enough support should be given to the top coal by timbering, roof bolting, or a combination of both to prevent the roof coal from sagging away from the overlying shale.

The experience in some of the newer mines in the Central Coal Basin where this practice has been followed has been very satisfactory, and no difficulty has been experienced because of deterioration of the roof due to atmospheric conditions.

4/ Fish, Edward L., Turnbull, Louis A., Toenges, Albert L., and Hartmann, Irving, A Study of Summer Air Conditioning with Water Sprays to Prevent Roof Falls at the Beech Bottom Coal Mine, West Virginia: Bureau of Mines Rept. of Investigations 3775, 1944, Appendix.

5/ Hartmann, Irving, and Greenwald, H. P., Effect of Changes in Moisture and Temperature on Mine Roof: Bureau of Mines Rept. of Investigations 3588, 1941, 40 pp.

Generated on 2024-09-20 10:47 GMT / https://hdl.handle.net/2027/osu.32435030643654
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY